

Summary of Research

for

NASA Grant NAG5-12770

Development of a Miniature L-band Radiometer for Education Outreach in Remote Sensing

PI: Lyon B. King
Department of Mechanical Engineering
Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931

ABSTRACT

Work performed under this grant developed a 1.4-Mhz radiometer for use in soil moisture remote sensing from space. The resulting instrument was integrated onto HuskySat. HuskySat is a 30-kg nanosatellite built under sponsorship from the Air Force Research Laboratory and NASA. This report consists of the interface document for the radiometer (the Science Payload of HuskySat) as detailed in the vehicle design report.

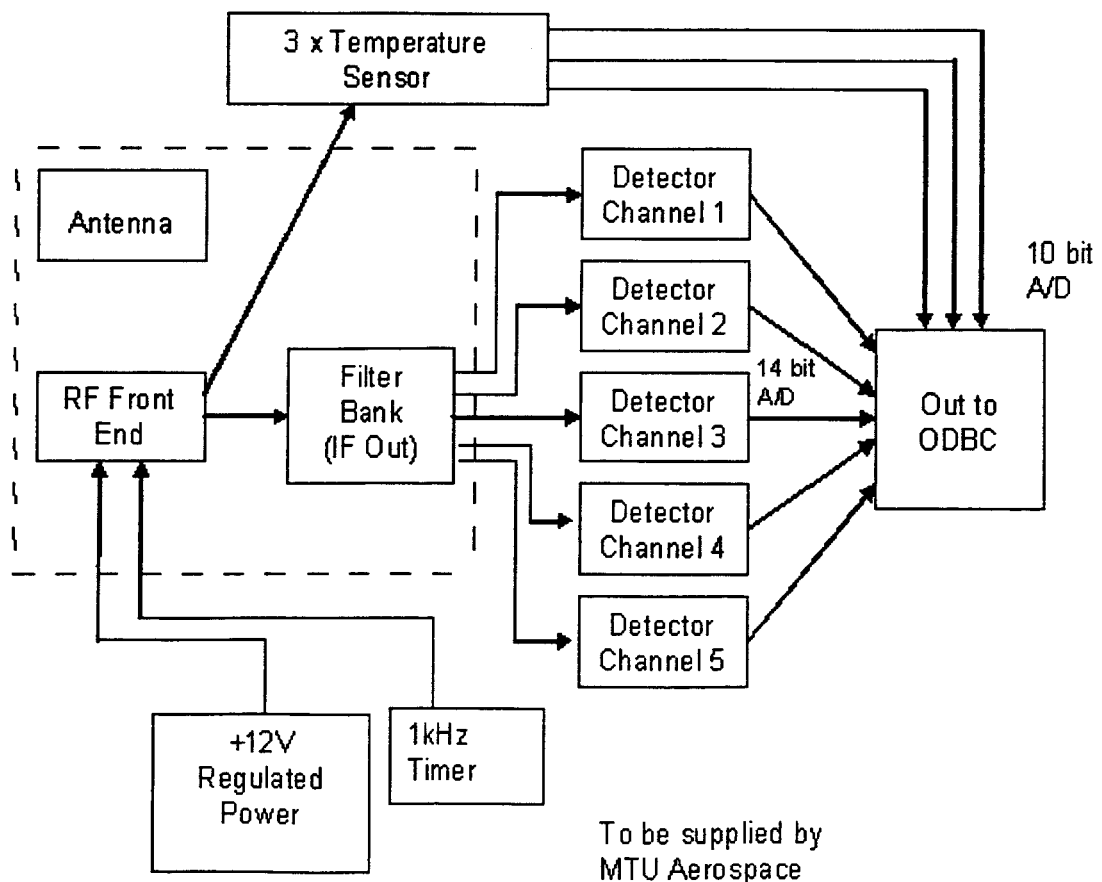
1. Science Payload

1.1. Subsystem Requirements

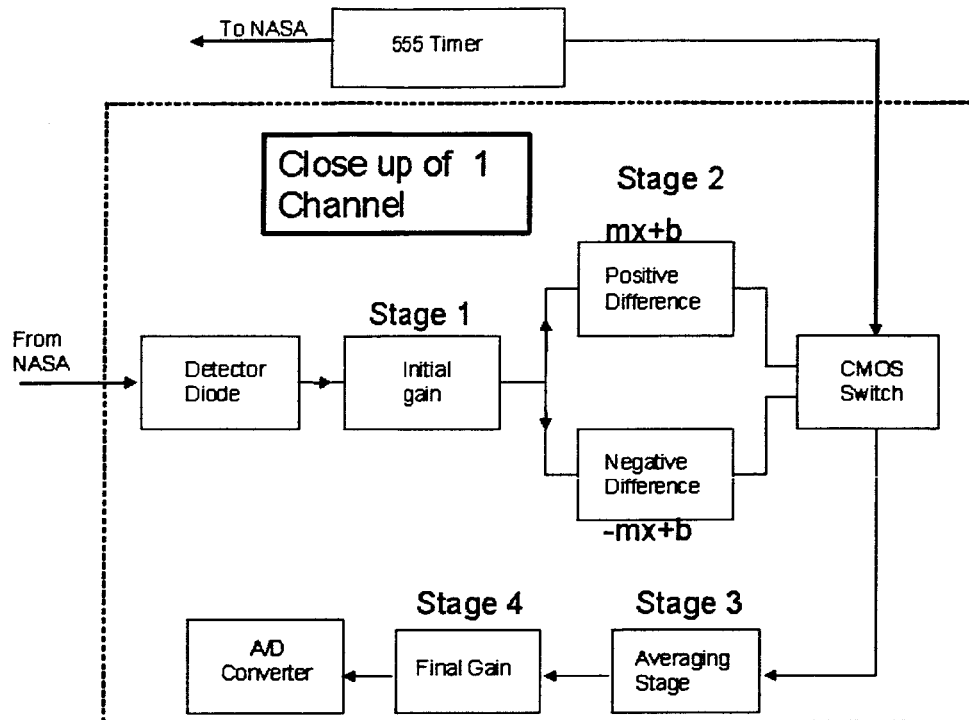
No.	Requirement	Status
1	Detect Earth L-band emissions at about -90dbm at 1.4Ghz	Procurement
2	Five Channels (1395, 1405, 1415, 1425, 1435MHz)	Procurement
3	5 MHZ bandwidth per channel	Procurement
4	Measure RF Switch Temperature	Prototype
5	Measure Antenna Temperature	Prototype
6	Measure RF Amplifier Temperature	Prototype

1.2. Technical Description of Subsystem

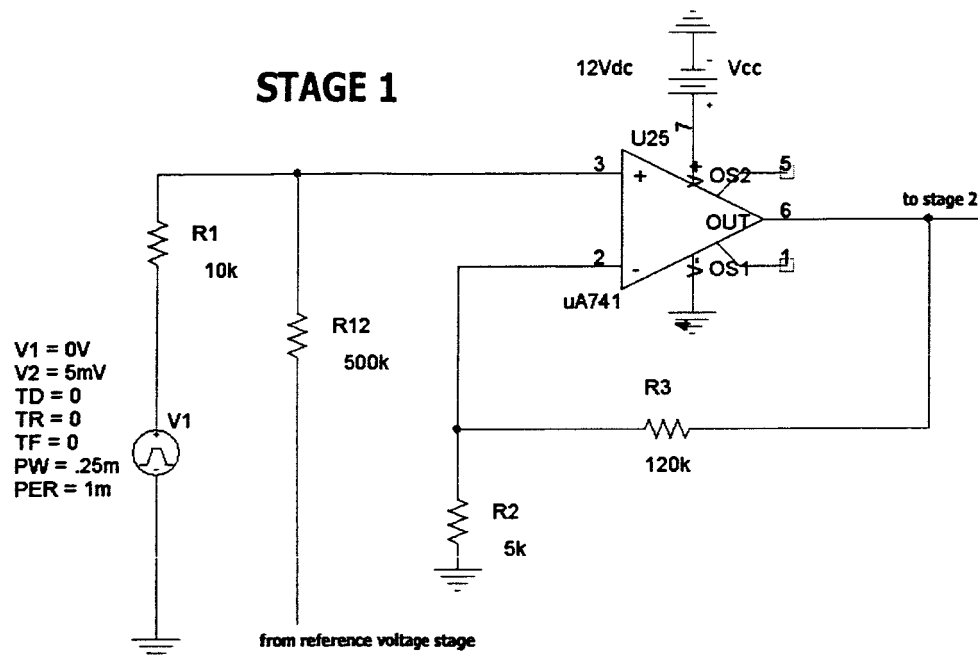
1.2.1 System Block Diagram 1



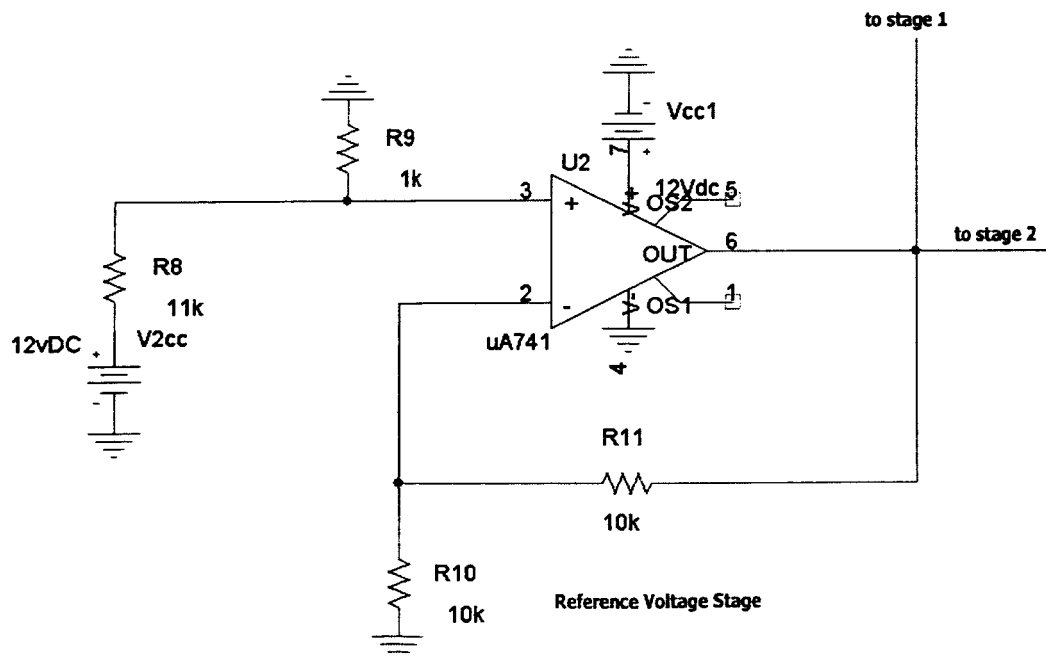
1.2.2 System Block Diagram 2



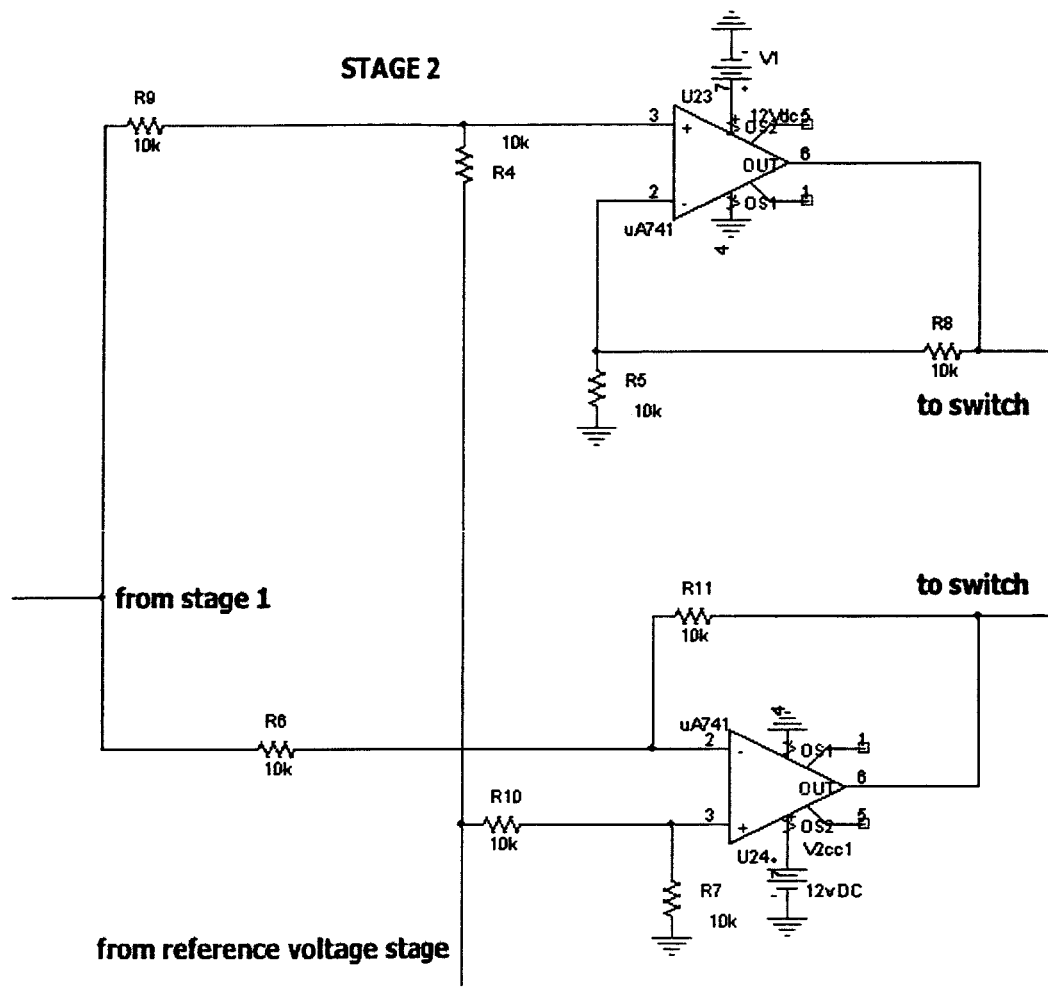
1.2.3 Stage 1 Of Detector Board



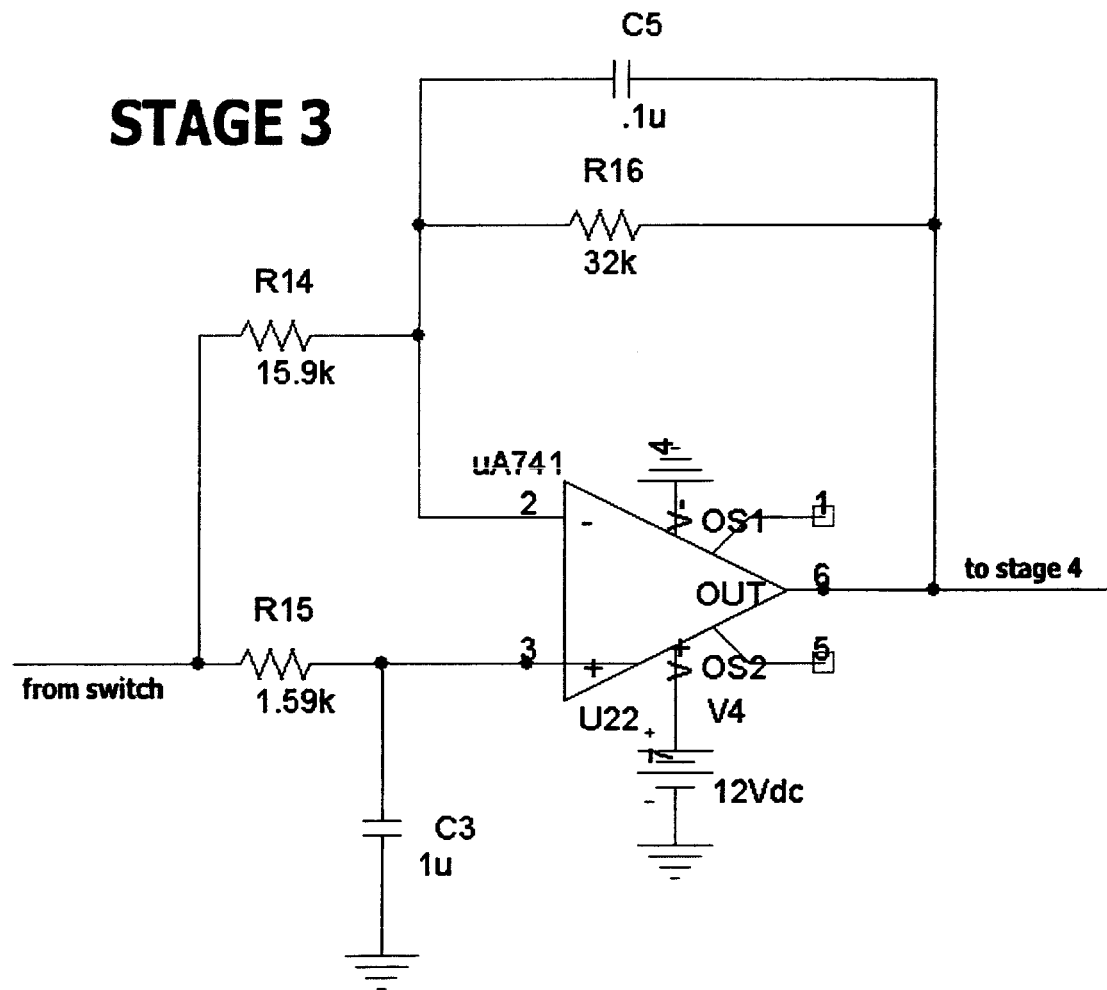
1.2.4 Buffer/Reference Voltage Stage



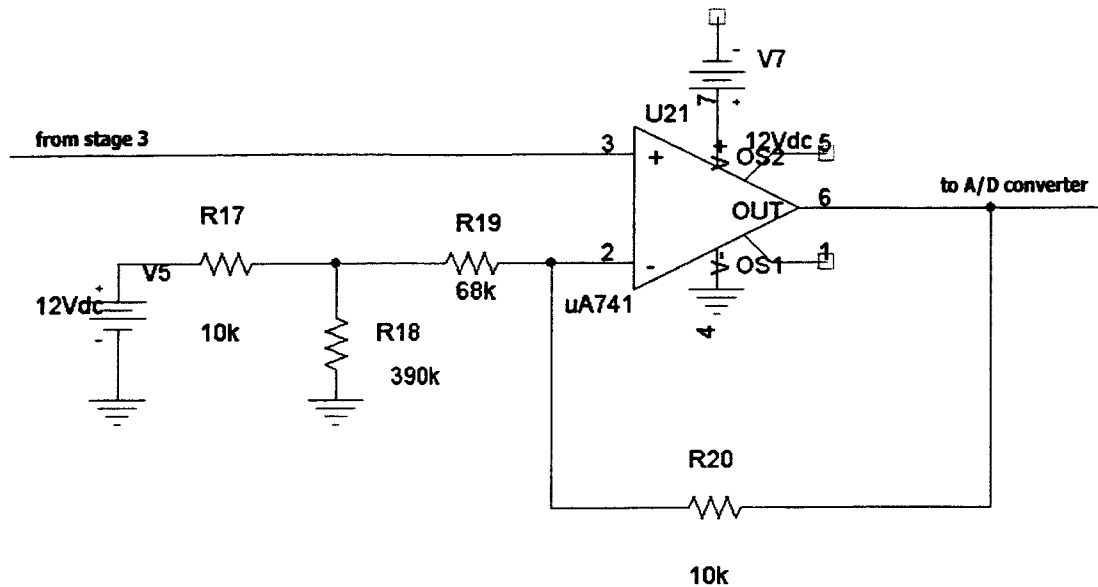
1.2.5 Stage 2 of Detector Board



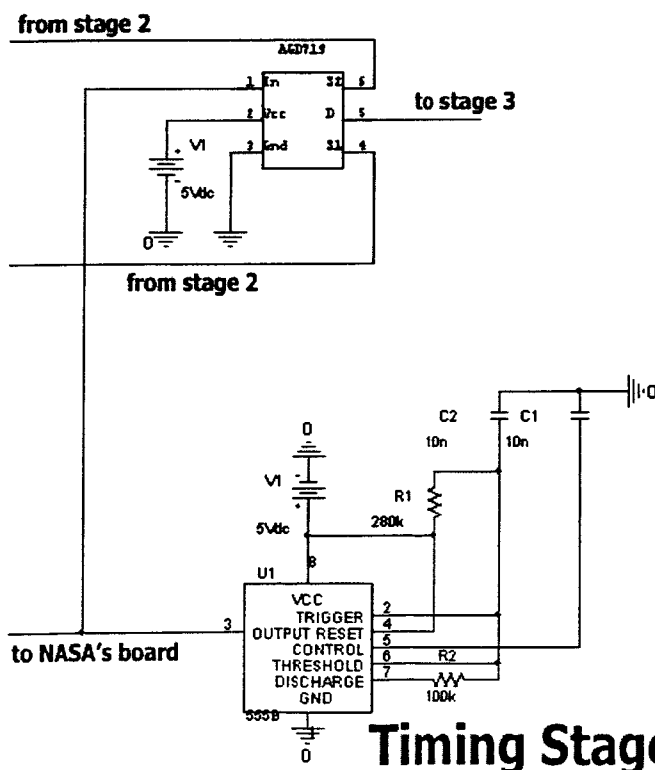
1.2.6 Stage 3 of Detector Board



1.2.7 Stage 4 of Detector Board



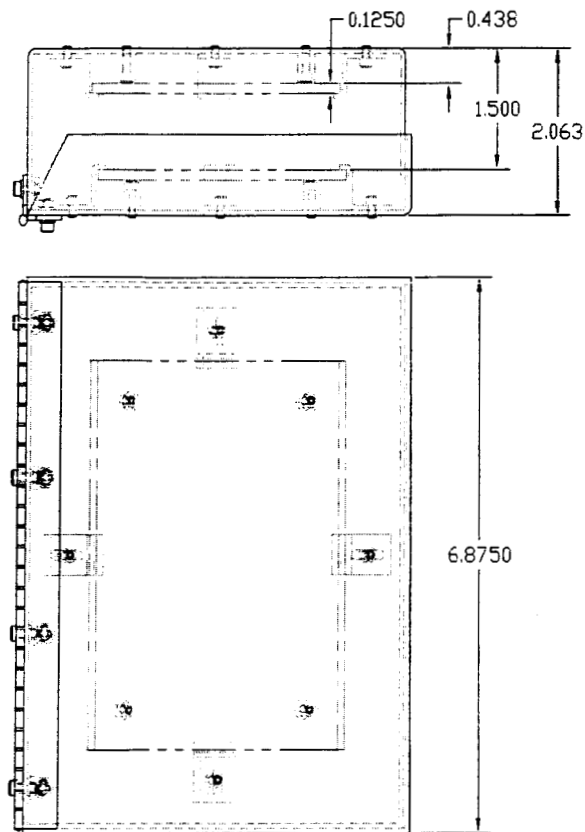
1.2.8 Timing stage of Detector Board



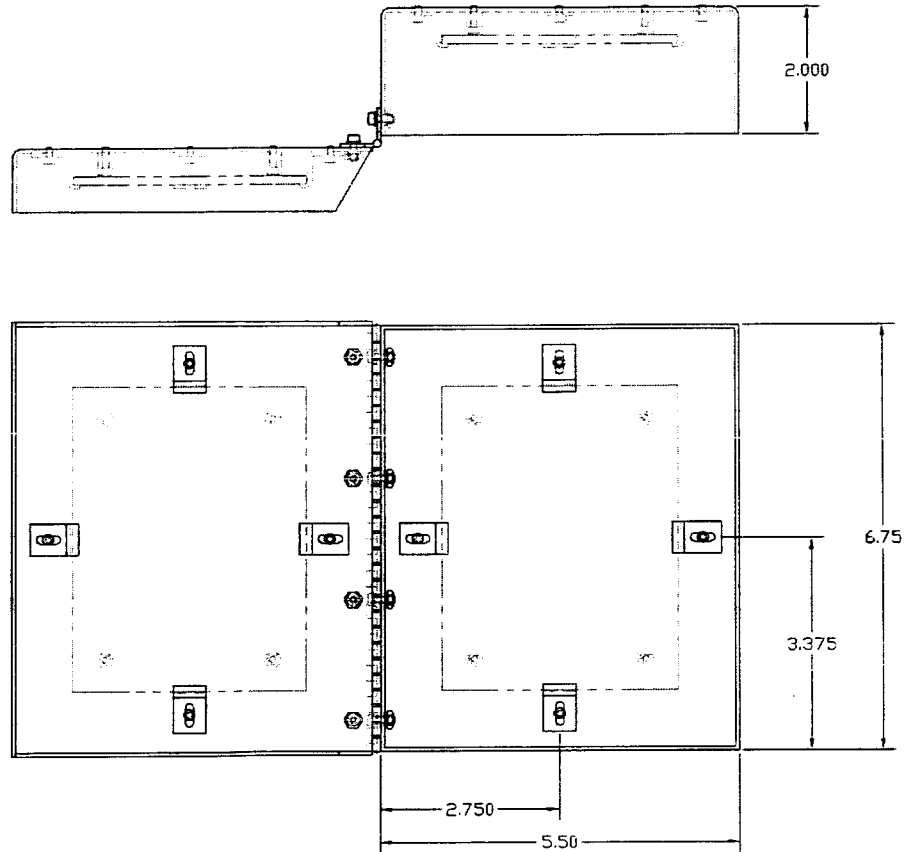
**Not Finalized*

1.2.9 Component Box Conceptual Drawings

Box closed



Box open



1.3. Subsystem Interfaces

1.3.1. Structural Interfaces

Qty.	Description	Dimensions (cm)	Mass (kg)	Mass Confidence	Impact rating	Protrusion?
1	Detector + RF Section	5x7x2 inches	<1.5	3	.0833	No
1	Antenna	Described below	0.5	4	.20833	Yes
1	Component Box	6.875x5.5x2.1 inches	0.5	2	.04167	No

TOTAL ON SATELLITE SUBSYSTEM MASS = ~ 2.5 kg

Description of Protrusions

Antenna will be less than 1 inch thick, and will encompass most of the nadir deck surface

1.3.2. Power Interfaces

Description	Voltage (V)	Current (I)	Confidence	Continuous?
Detector board supply voltage	12 & 5	<41mA	3	Yes
RF board supply voltage	12	<170mA	3	Yes

Itemized description of non-continuous power needs

N/A

1.3.3. Data Interfaces

ANALOG OUTPUTS

Qty.	Description	Range	Sci/Health
1	Science Channel 1	0-5V	Sci
1	Science Channel 2	0-5V	Sci
1	Science Channel 3	0-5V	Sci
1	Science Channel 4	0-5V	Sci
1	Science Channel 5	0-5V	Sci
3	Temperature Sensors	0-5V	Health

ANALOG INPUTS

Qty.	Description	Range	Sci/Health
N/A	N/A	N/A	N/A

DIGITAL OUTPUTS

Qty.	Description	Science/Health?
N/A	N/A	N/A

DIGITAL INPUTS

Qty.	Description	Science/Health?
1	TTL to Disable/Enable Timer Ckt (disconnect from L-band Antenna during Telecom Transmit)	Health

1.3.4. Software Services Required

Description	Operational Mode	Trigger	Response Time (sec)	Min Rep Period (sec)
Record Science Data	Active Science		N/A	N/A
Command to disconnect from L-band Antenna	Active Science	Whenever Telecom Downlink is activated	Before Telecom goes active	N/A

Command to restart switch timer	Active Science	When Telecom downlink is complete	After Telecom downlink complete	N/A
Record Temperature Data	Active Science	When Science Data begins to Record	N/A	N/A

1.3.5. *Thermal Interfaces*

*Does not include RF section parts at this time.

Description	Min Operating Temp (C)	Max Operating Temp (C)	Heat Source?	Power Dissipated (W)	Power Dissipated Confidence
ADG719 CMOS Switch	-40	125	No		
NTC Thermistor Type NHQ	-40	125	Yes	3mW/K	4
OPA2241 Op-Amp	-40	85	No		
TLC555IDR	-40	85	Yes	0.5W	2
HSMS 2850 Detector Diode	-65	150	No		

1.4. *Subsystem Flight Hardware Parts List*

Qty.	Description	Vendor	Lead Time	Cost Each	Price	Purchased Y/N
55	10K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$23.65	Y
5	5K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$2.15	Y
5	500K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$2.15	Y
5	120K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$2.15	Y
5	11K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$2.15	Y
5	1K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$2.15	Y
5	1.6K Ohm	Digi-Key	7-10	\$0.43	\$2.15	Y

This document was published 05/10/04. No additional changes will be made to it. Check for updates at <http://www.enterprise.mtu.edu/aerospace/>.

	Resistor		Days			
5	32K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$2.15	Y
5	16K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$2.15	Y
1	100K Ohm Resistor	Digi-Key	7-10 Days	\$0.43	\$0.43	Y
1	280K Ohm Resistor	Digi Key	7-10 Days	\$0.43	\$0.43	Y
15	OPA2241 Op-Amp	Digi-Key	7-10 Days	\$4.28	\$64.20	Y
5	1 μ -Farad Capacitor	Digi-Key	7-10 Days	\$0.0325	\$0.16	Y
5	0.1 μ -Farad Capacitor	Digi-Key	7-10 Days	\$0.0325	\$0.16	Y
5	ADG719 CMOS Switch	Digi-Key	7-10 Days	\$1.65	\$8.25	Y
1	TLC 555 Timer	Digi-Key	7-10 Days	\$0.72	\$0.72	Y
5	HSMS Detector Diode					

1.5. Subsystem Supporting Parts List

Description	Part Number	QTY	Vender	Unit Price	Price
Punchboard--4.5"Wx6.5"L/0.042 DIA		1	Vector		
68786-302		10			
Low Voltage Single SPDT	PE4246-01	15	ADI PE		
IC Dual OP AMP 8-SOIC	296-9553-5-ND	25	Digi-Key	0.34	8.50
IC Single LV R-R OP AMP SC-70-5	LMV321IDCKR	6			
HSMS 2850 BLK U1004					
IC Micro Power OPAMP SO-8	OPA251UA	3			
IC OP AMP CMOS Single Supply 8-SOIC	OPA2335AIDR	3			
IC 3.3V 150MA LDO REG 8-SOIC	296-2720-5-ND	10			
ADG719BRM		14			

This document was published 05/10/04. No additional changes will be made to it. Check for updates at <http://www.enterprise.mtu.edu/aerospace/>.

	GALI-S66	30			
CRCW0603249F100		20			
Low Dropout (LDO) Voltage Regulator	TPS76533D	3			
IC Micro Power LV OPAMP SO-8	OP241UA	3			
IC CMOS TIMER 8-SOIC	296-1337-1-ND	25	Digi-Key	0.60	15.00
IC Dual Micro Power OP AMP 8-Dip	OPA2241PA-ND	6	Digi-Key	4.28	25.68
RES 10.0K OHM 1/16W 1% 0603 SMD	311-10.0KCT-ND	200	Digi-Key		
RES 11 OHM 1/16W 5% 0603 SMD	P11GCT-ND	50	Digi-Key	0.43	2.15
RES 13 OHM 1/16W 5% 0603 SMD	P13GCT-ND	50	Digi-Key	0.43	2.15
RES 16 OHM 1/16W 5% 0603 SMD	P16GCT-ND	50	Digi-Key	0.43	2.15
RES 20 OHM 1/16W 5% 0603 SMD	P20GCT-ND	50	Digi-Key	0.43	2.15
RES 24 OHM 1/16W 5% 0603 SMD	P24GCT-ND	50	Digi-Key	0.43	2.15
RES 30 OHM 1/16W 5% 0603 SMD	P30GCT-ND	50	Digi-Key	0.43	2.15
RES 36 OHM 1/16W 5% 0603 SMD	P36GCT-ND	50	Digi-Key	0.43	2.15
RES 43 OHM 1/16W 5% 0603 SMD	P43GCT-ND	50	Digi-Key	0.43	2.15
RES 51 OHM 1/16W 5% 0603 SMD	P51GCT-ND	50	Digi-Key	0.43	2.15
RES 62 OHM 1/16W 5% 0603 SMD	P62GCT-ND	50	Digi-Key	0.43	2.15

RES 75 OHM 1/16W 5% 0603 SMD	P75GCT-ND	50	Digi- Key	0.43	2.15
RES 91 OHM 1/16W 5% 0603 SMD	P91GCT-ND	50	Digi- Key	0.43	2.15
RES 110 OHM 1/16W 5% 0603 SMD	P110GCT-ND	50	Digi- Key	0.43	2.15
RES 130 OHM 1/16W 5% 0603 SMD	P130GCT-ND	50	Digi- Key	0.43	2.15
RES 160 OHM 1/16W 5% 0603 SMD	P160GCT-ND	50	Digi- Key	0.43	2.15
RES 200 OHM 1/16W 5% 0603 SMD	P200GCT-ND	50	Digi- Key	0.43	2.15
RES 240 OHM 1/16W 5% 0603 SMD	P240GCT-ND	50	Digi- Key	0.43	2.15
RES 300 OHM 1/16W 5% 0603 SMD	P300GCT-ND	50	Digi- Key	0.43	2.15
RES 360 OHM 1/16W 5% 0603 SMD	P360GCT-ND	50	Digi- Key	0.43	2.15
RES 430 OHM 1/16W 5% 0603 SMD	P430GCT-ND	50	Digi- Key	0.43	2.15
RES 510 OHM 1/16W 5% 0603 SMD	P510GCT-ND	50	Digi- Key	0.43	2.15
RES 620 OHM 1/16W 5% 0603 SMD	P620GCT-ND	50	Digi- Key	0.43	2.15
RES 750 OHM 1/16W 5% 0603 SMD	P750GCT-ND	50	Digi- Key	0.43	2.15
RES 910 OHM 1/16W 5% 0603 SMD	P910GCT-ND	50	Digi- Key	0.43	2.15

RES 1.1K OHM 1/16W 5% 0603 SMD	P1.1KGCT-ND	50	Digi- Key	0.43	2.15
RES 1.3K OHM 1/16W 5% 0603 SMD	P1.3KGCT-ND	50	Digi- Key	0.43	2.15
RES 1.6K OHM 1/16W 5% 0603 SMD	P1.6KGCT-ND	50	Digi- Key	0.43	2.15
RES 2.4K OHM 1/16W 5% 0603 SMD	P2.4KGCT-ND	50	Digi- Key	0.43	2.15
RES 3.0K OHM 1/16W 5% 0603 SMD	P3.0KGCT-ND	50	Digi- Key	0.43	2.15
RES 3.6K OHM 1/16W 5% 0603 SMD	P3.6KGCT-ND	50	Digi- Key	0.43	2.15
RES 4.3K OHM 1/16W 5% 0603 SMD	P4.3KGCT-ND	50	Digi- Key	0.43	2.15
RES 5.1K OHM 1/16W 5% 0603 SMD	P5.1KGCT-ND	50	Digi- Key	0.43	2.15
RES 6.2K OHM 1/16W 5% 0603 SMD	P6.2KGCT-ND	50	Digi- Key	0.43	2.15
RES 7.5K OHM 1/16W 5% 0603 SMD	P7.5KGCT-ND	50	Digi- Key	0.43	2.15
RES 9.1K OHM 1/16W 5% 0603 SMD	P9.1KGCT-ND	50	Digi- Key	0.43	2.15
RES 11K OHM 1/16W 5% 0603 SMD	P11KGCT-ND	50	Digi- Key	0.43	2.15
RES 13K OHM 1/16W 5% 0603 SMD	P13KGCT-ND	50	Digi- Key	0.43	2.15
RES 16K OHM 1/16W 5% 0603 SMD	P16KGCT-ND	50	Digi- Key	0.43	2.15

RES 20K OHM 1/16W 5% 0603 SMD	P20KGCT-ND	50	Digi- Key	0.43	2.15
RES 24K OHM 1/16W 5% 0603 SMD	P24KGCT-ND	50	Digi- Key	0.43	2.15
RES 30K OHM 1/16W 5% 0603 SMD	P30KGCT-ND	50	Digi- Key	0.43	2.15
RES 36K OHM 1/16W 5% 0603 SMD	P36KGCT-ND	50	Digi- Key	0.43	2.15
RES 43K OHM 1/16W 5% 0603 SMD	P43KGCT-ND	50	Digi- Key	0.43	2.15
RES 51K OHM 1/16W 5% 0603 SMD	P51KGCT--ND	50	Digi- Key	0.43	2.15
RES 62K OHM 1/16W 5% 0603 SMD	P62KGCT-ND	50	Digi- Key	0.43	2.15
RES 75K OHM 1/16W 5% 0603 SMD	P75KGCT-ND	50	Digi- Key	0.43	2.15
RES 91K OHM 1/16W 5% 0603 SMD	P91KGCT-ND	50	Digi- Key	0.43	2.15
RES 110K OHM 1/16W 5% 0603 SMD	P110KGCT-ND	50	Digi- Key	0.43	2.15
RES 130K OHM 1/16W 5% 0603 SMD	P130KGCT-ND	50	Digi- Key	0.43	2.15
RES 160K OHM 1/16W 5% 0603 SMD	P160KGCT	50	Digi- Key	0.43	2.15
RES 200K OHM 1/16W 5% 0603 SMD	P200KGCT	50	Digi- Key	0.43	2.15
RES 240K OHM 1/16W 5% 0603 SMD	P240KGCT	50	Digi- Key	0.43	2.15

RES 300K OHM 1/16W 5% 0603 SMD	P300KGCT	50	Digi-Key	0.43	2.15
RES 360K OHM 1/16W 5% 0603 SMD	P360KGCT	50	Digi-Key	0.43	2.15
RES 430K OHM 1/16W 5% 0603 SMD	P430KGCT	50	Digi-Key	0.43	2.15
RES 510K OHM 1/16W 5% 0603 SMD	P510KGCT	50	Digi-Key	0.43	2.15
RES 620K OHM 1/16W 5% 0603 SMD	P620KGCT	50	Digi-Key	0.43	2.15
RES 750K OHM 1/16W 5% 0603 SMD	P750KGCT	50	Digi-Key	0.43	2.15
RES 910K OHM 1/16W 5% 0603 SMD	P910KGCT	50	Digi-Key	0.43	2.15
CAP Ceramic 390PF 50V 0603 SMD	PCC391ACVCT-ND	20	Digi-Key	0.118	2.36
CAP Ceramic 330PF 50V 0603 SMD	PCC331ACVCT-ND	20	Digi-Key	0.118	2.36
CAP 470PF Ceramic NPO0603	PCC2147CT-ND	20	Digi-Key	0.118	2.36
RES 20.0 OHM 1.16W 1% 0603 SMD	P20.0HCT-ND	200	Digi-Key	0.02785	5.57
Thermistor 10K OHM BTC SMT 0805	BC1518CT-ND	100	Digi-Key	0.2805	28.05
CAP 1000PF 50V Ceramic X7R 0603	311-1080-1-ND	100	Digi-Key	0.0325	3.25
RES 1.00K OHM 1/16W 1% 0603 SMD	311-1.00KCT-ND	200	Digi-Key		
RES 20.0 OHM 1.16W 1% 0603 SMD	P20.0HCT-ND	200	Digi-Key	0.02785	5.57
RES 6.81 OHM 1/16W 1% 0603 SMD	311-6.81HCT-ND	20	Digi-Key	0.077	1.54
RES 6.04 OHM 1/16W 1% 0603 SMD	311-6.04HCT-ND	20	Digi-Key	0.077	1.54

CONN Jack End Launch PC Gold SMA	J658-ND	10	Digi-Key	5.187	51.87
Inductor 1.6x0.8x0.8mm 120NH	334-1024-1-ND	30	Digi-Key	0.75	22.5
RES 88.7 OHM 1/16W 1% 0603 SMD	P88.7HCT	50	Digi-Key	0.0484	2.42
CAP Ceramic 120PF 50V 0603 SMD	PCC121ACVCT-ND	20	Digi-Key	0.062	1.24
CAP Ceramic 180PF 50V 0603 SMD	PCC181ACVCT-ND	20	Digi-Key	0.062	1.24
Thermistor 10K OHM NTC SMT 0805	BC1518CT-ND	100	Digi-Key	0.2805	28.05
Inductor 1.0 +/-0.2NH 0603	408-1025-1-ND	20	Digi-Key	0.17	3.40
Inductor 1.8 +/-0.2NH 0603	408-1028-1-ND	20	Digi-Key	0.17	3.40
Inductor 2.2 +/-0.2NH 0603	408-1029-1-ND	20	Digi-Key	0.17	3.40
Inductor 4.7 +/-0.2NH 0603	408-1033-1-ND	20	Digi-Key	0.17	3.40
Inductor 10NH +/-0.2 0603	408-1037-1-ND	20	Digi-Key	0.17	3.40
Inductor 15NH +/-0.2 0603	408-1039-1-ND	20	Digi-Key	0.17	3.40
CAP 0.5PF 50V Ceramic 0603 SMD	PCC0R5CVCT-ND	20	Digi-Key	0.067	1.34
CAP Ceramic 1.0PF 50V NP0 0603	BC1223CT-ND	20	Digi-Key	0.059	1.18
CAP Ceramic 1.5PF 50V NP0 0603	399-1046-1-ND	20	Digi-Key	0.407	8.14
CAP 2.0PF 50V Ceramic 0603 SMD	PCC020CVCT-ND	20	Digi-Key	0.067	1.34
CAP 4.0PF 50V Ceramic 0603 SMD	PCC040CVCT-ND	20	Digi-Key	0.067	1.34
CAP Ceramic 6.0PF 50V NP0 0603	311-1055-1-ND	20	Digi-Key	0.066	1.32
CAP 7.0PF 50V Ceramic 0603 SMD	PCC070CVCT-ND	20	Digi-Key	0.067	1.34
CAP Ceramic 10PF 50V NP0 0603	311-1058-1-ND	20	Digi-Key	0.057	1.14
CAP 10000PF 50V Ceramic NP0 0603	399-1091-1-ND	30	Digi-Key	0.042	1.26
CAP .10UF 25V Ceramic Y5V 0603	399-1100-1-ND	100	Digi-Key	0.0325	3.25

RES 30.9K OHM 1/16W 1% 0603	311-30.9KHCT-ND	20	Digi-Key	0.09	1.8
RES 73.2K OHM 1/16W 1% 0603	311-73.2KHCT-ND	20	Digi-Key	0.09	1.8

TOTAL COST OF SUBSYSTEM = 

1.6. Test Procedures and Setup Report Index

Title	File Number	Description	Completed Y/N